Grooming Behavior in Embioptera and Zoraptera (Insecta)[1]

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ABSTRACT. Embiid grooming (based on *Oligembia (D.) vandykei* Ross, and two unidentified species) includes five acts, all involving the mouth as the effector organ: Antenna Clean, Foreleg Clean, Midleg Clean, Hindleg Clean, and Abdomen Clean. Of these, only Antenna Clean is unusual because the antenna is unassisted by a foreleg, and is turned under the body and supported by the substrate as the head dips to reach it. Zorapteran grooming (*Zorotypus hubbardi* Caudell) includes 10 acts which can be performed in 13 ways. Alternate ways occur in Midleg Clean and Palpus Clean. The remaining eight acts are: Antenna Clean, Foreleg Clean, Hindleg Clean, Abdomen Clean, Antenna-Foreleg Rub, Head-Foreleg Rub, Body-Foreleg Rub, and Body-Substrate Rub. Modes unknown in other insects occur in Midleg Clean (with both forelegs raised), and Abdomen Clean (body forming a closed upside-down U, on a 4-point stance, the forelegs raised). Grooming behavior of embiids and zorapterans does not suggest relationships with other insect orders, and emphasizes their isolation.

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INTRODUCTION

Grooming behavior for most insect orders is poorly known, despite the insight it provides by relating structure to function. Of the two orders described here, zorapterans have no precisely reported grooming behavior and embiopterans have two reported movements. Recent data fill many gaps in our knowledge and are suggestive of the final patterns to be expected when larger samples are available. Although samples were small, extensive observations of other insects (over 1,700 hrs.) revealed little variation and no sexual dimorphism in the grooming behavior of conspecific individuals.

Jander (1966) reported only two grooming movements in an unidentified embiid from Tunisia; the specimen was removed from its tunnel system and observed on a small stone partly submerged in a bowl of water. The two movements she observed (which I call Antenna Clean and Foreleg Clean) are duplicated in the repertory of the individuals I studied. Ross (1944) and papers cited therein were checked, but grooming was not discussed.

Gurney (1938) published a summary of the Zoraptera. The 16 species known to him have now been increased to 22, but there has been no significant increase in the knowledge of the biology or behavior of these insects. I found no reference to grooming in Shetlar (1978) and other literature on the order, except Gurney's statement (p.65) that "Individuals move about, frequently stopping to clean their antennae and tarsi."

METHODS AND MATERIALS

Two apterous embiopterans (female and juvenile) were collected by the author, 18 March 1978, in Florida, Charlotte County, Cole Island (at north end of Gasparilla Island), on the sandy Gulf beach above the high tide line under an accumulation of broken pine branches and debris. These individuals were observed with a dissecting microscope on 26 March 1978, from 1915 to 2100 hrs, and for four additional hours the next day. The observations on the second day duplicted but did not modify the data from the first day. Observations were made when the embiids were without a tunnel system, while a system was under construction, and after a series of interconnecting tubes had been built. Most grooming took place within tunnels. The observation chamber was excavated in a flat block of damp plaster of paris, covered tightly with a glass plate, and viewed with a red filter on the microscope light. An alate male *Oligembia (Dilobocera) vandykei* Ross, 1944 (Family Oligembiidae) was collected in Florida, Monroe County, Bahia Honda Key, Sandspur Beach, on 25 December 1979, by the author after a light rain, and was observed in a vial immediately after capture from 0900 to 0945 hrs.

The specimens of Zoraptera were collected by the author in Florida, Charlotte County, 7.2 km NE Placida on Florida route 771, on 22 March 1978. A male and a female *Zorotypus hubbardi* Caudell 1918, both apterous, provided the present data. They were under the bark of a red-rotten pine log of the type described by Valentine and Wilson (1949), which was lying in tall grass and weeds after having been bulldozed at a dormant construction site. They were observed for 4.5 hours on 26 March (1400 to 1630 hrs in separate cavities and 1630 to 1830 hrs together), and then intermittently for over six hours during the next three days with no new movements seen. The high humidity observation chamber was similar to that used for the embiids.

RESULTS

As described elsewhere (Valentine 1973, Valentine and Glorioso 1979), grooming involves two major techniques: CLEANING in which the receptor is groomed by the mouth, and RUBBING in which the receptor is groomed by one or more legs or the substrate. A third aspect of the grooming process, POSITIONING, is not involved in the present study. For clarity, the terminology of grooming movements always names the receptor structure first. This works for all situations except mutual leg rubs, where the mutual movement must be noted.

GROOMING IN EMBIOPTERA

Cleaning

Antenna Clean. In most insects, an antenna is pulled down to the mouth by a foreleg. In the embiids studied, an antenna deflects downward and backward using its basal musculature until it is directed posteriorly under the head which then lowers and traps the antenna between the mouthparts and the substrate. The antenna is groomed deliberately with both mandibles and maxillae moving, and gradually passes anteriorly through the mouth as the dorsal surface rubs against the substrate. The movement can be performed equally well with the embiid on the side walls or suspended upside down in its tunnel system, or when the insect is removed from the tunnels.

Foreleg Clean. A foreleg is groomed deliberately while passing posteriorly through the mouth, claws last.

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The head dips down to the raised limb and can reach from the coxa to the claws. The enlarged basal segment of the tarsus is groomed along the articular, lateral, or dorsal sides, with the different surfaces being cleaned during different passes through the mouthparts.

Midleg Clean. The midleg is brought forward ventro-laterally, under the foreleg which is raised or remains on the substrate; the head dips down and to the side to reach it. The limb is groomed deliberately; the mouthparts can reach anywhere from the coxa to the claws, and the leg moves posteriorly or else the head is raised as the grooming progresses. At times, the mouth can push the leg against the tunnel wall as if to get a better grip; this act can be performed with the insect upside-down in its tunnel.

Hindleg Clean. In this movement, the embiid lies on its side or back with its head and thorax doubled into a C. Either or both ipsilateral foreleg and midleg are held in midair or touching the tube wall, and the mouthparts groom any part of the hind leg, from the coxa to the claws.

Abdomen Clean. The body is bent double and the mouthparts can groom at least abdominal sternites 6 to 10, the cerci, or the ventral and lateral surfaces of the anal and genital regions. Grooming of the basal abdominal segments and of the entire dorsum was not seen, but there appear to be few or no constraints in the areas that can be groomed.

GROOMING IN ZORAPTERA

Antenna Clean. *Zorotypus,* in contrast to the embiids, is similar to many other insects, using the foreleg method and the held mode. The ipsilateral foreleg pulls the antenna down to the mouth and remains to help hold the antenna in place while it is groomed by the mouthparts. This technique has been observed in our laboratory in specimens of Diplura, Thysanura, Blattaria, Mantodea, jumping Orthoptera, Dermaptera, planipennian Neuroptera, and Coleoptera. All of these orders, except the Zoraptera, also use the free mode where the antenna is held by the mouthparts and the foreleg is held in midair or returned to the substrate. The absence of free mode in *Zorotypus* may be sampling error.

Foreleg Clean. This movement is similar to embiids and is widespread in insects, occurring in at least 17 mandibulate orders.

Midleg Clean. This is also similar to embiids, but less stereotyped. Usually the ipsilateral foreleg remains unmoved on the substrate; however, it may be raised. On three occasions, the act was performed on a three-point stance with the anterior body and both forelegs raised. Eleven mandibulate insect orders use the first technique, but we have seen no other insect cleaning the midleg with both forelegs raised.

Hindleg Clean. A hindleg is brought forward under the arched body and the head lowers to reach it. Grooming movements can extend from the coxa to the claws, but often only the tarsus is cleaned. This ventral mode occurs in 12 orders, the others being Collembola, Diplura, Blattaria, Isoptera, Orthoptera, Embioptera, Dermaptera, Psocoptera, Rhaphidiaria, plannipennian Neuroptera, and Coleoptera.

Abdomen Clean. *Zorotypus* can clean at least the posterior three sternites, the cerci, and genital-anal area. The movement is unique, involving the body raised high on a four-point stance on the mid- and hindlegs, the forelegs raised and held in midair, and anterior and posterior ends of the body both bent down and meeting between the mid- and hindlegs like a closed horseshoe standing on the two ends. Some other insects can bend the abdomen into the mouth, but do so with the two ends of the body parallel to the substrate, not perpendicular.

Palpus Clean. The maxillary palpi are cleaned by two methods: a palpus tip can curl into the mouth from a position anterior to the labrum and be withdrawn anteriorly, or it can enter the mouth from the rear and be withdrawn posteriorly. In the latter case, it is usually held in place by the ipsilateral foreleg. The labial palpi are also cleaned with what appears to be the posterior method. Of 11 orders which have been observed cleaning the maxillary palpi, only the Zoraptera have both methods just described. Only six orders are known to clean the labial palpi: Thysanura, Blattaria, Mantodea, Orthoptera, Zoraptera, and Neuroptera. We assume that the act occurs in some other orders, but to see it requires that the insect be perfectly oriented.

Rubbing

Antenna-Foreleg. In those insects that groom the antennae by passing them through the mouthparts, there is also a characteristic rubbing movement usually confined to those basal antennal segments which can never reach the mouth. The antennae are directed forward and a foreleg rubs the dorsal surface of the basal segments of the ipsilateral antenna. In some other insects, the eyes or adjacent portions of the head capsule are included. In *Zorotypus,* the antennal base receives multiple, rapid vibration-like strokes, apparently without involving the head surface. In a second method, unique to Zoraptera, the antennae are raised and directed posteriad above the body; in this position a foreleg rubs the ventral base of the ipsilateral antenna.

Head-Foreleg. Some type of Head Rub occurs in almost every insect order. In Zoraptera it consists of unilateral, multiple, rapid vibration-like strokes on any portion of the head (except the contralateral side), including the labrum and the ipsilateral maxillary or labial palp.

Body-Foreleg. This movement is usually combined with the preceding, but can also be performed independently. It consists of multiple, rapid foreleg strokes on the dorsal or lateral surfaces of the prothorax.

Body-Substrate. This may be either pheromonal communication, or grooming, or both; it consists of briefly dragging the abdominal tip while running. This act was performed twice by the isolated female, but not by the male. Prolonged courtship began immediately after placing the male in the female's chamber, about 15 minutes later.

DISCUSSION

The embiid repertory described above includes only cleaning movements that use the mouth as the grooming effector. The absence of rubbing acts is a striking departure from the grooming patterns of most other insects. Rubbing may be a part of the embiid repertory, but several hours of observations, with frequent grooming activity confined to cleaning, clearly suggests that, if present, rubbing is at best a minor component. The

heavy emphasis on oral grooming is characteristic of the insect orders Microcoryphia, Thysanura, and the orthopteroid complex, including Blattaria, Isoptera, Mantodea, and Orthoptera (I have no data for Phasmida and Grylloblattodea). Of these, the Blattaria and Orthoptera have the greatest diversity of rubbing movements (Smith and Valentine 1986), but even in these two orders rubbing is only a minor part of the grooming repertory.

All the above orders have one or more rubbing movements except the embiids. It is logical to associate this grooming pattern with the unique silk-tunnel-system of these insects. The simplicity of embiid grooming (only 5 acts) is not due to constraint; the tunnels are very soft and elastic and are modified at will by the insects. I suspect that the simplicity is due to the embiids exceptionally sheltered existence. Living within silken tunnels isolates the insects from the various particulate materials of the adjacent habitat. There has been no selection for particle removal techniques, and grooming has been kept at (or reduced to) the essentials for the protected embiid life style: maintenance of the antennae, legs, and genital area achieved by one grooming act for each structure.

In Zoraptera, the grooming repertory is more extensive, involving 13 modes in 10 major acts. The increased diversity correlates with the more complex habitat. Zorapterans occur under the loose bark of rotten logs, often in association with termites and the ponerine ant genus *Proceratium*. Damp, soft pine logs and stumps appear to be optimal. A secondary habitat in old sawdust piles is also used extensively. In the 15 times I have observed *Zorotypus* in the field (Mississippi, Alabama, Florida, and Jamaica), 13 occasions involved rotten pine; only at sites in Alabama and Jamaica were the insects associated with deciduous hardwoods. At all sites the bark was sufficiently loose that the zorapterans had ample running room, so physical constraints do not now appear to be involved in the selection of grooming movements. Various sized particles of frass and fungus spores are present and have undoubtedly affected the selection of the modern repertory.

Embioptera and Zoraptera are both problematic orders with uncertain relationships. Grooming behavior does not clarify the problems. Embiid grooming contains four routine acts duplicated by many other mandibulate insects, and one act that is unusual.

Antenna Clean is performed by most mandibulate insects, but almost always assisted by a foreleg. In embiids, Antenna Clean is unassisted by the foreleg, and the substrate is used to support the antenna as the head lowers to reach it. This odd movement has been seen in our studies only in Collembola, Blattaria, and Psocoptera, an assortment that negates phylogenetic hypotheses.

The Zoraptera grooming repertory is equally uninformative. The two orders with suggestive morphology are the Isoptera and Psocoptera. Our samples of both orders are small, but the similarities between Zoraptera grooming and the emerging patterns of these two orders are confined to routine movements found in other widely dissimilar insects. Zorapterans share no rare or odd movements with any other order, and have two unique movements unknown elsewhere. At this point in our studies, grooming behavior emphasizes the isolation of Embioptera and Zoraptera from other insects, and does not support any pattern of relationship.

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